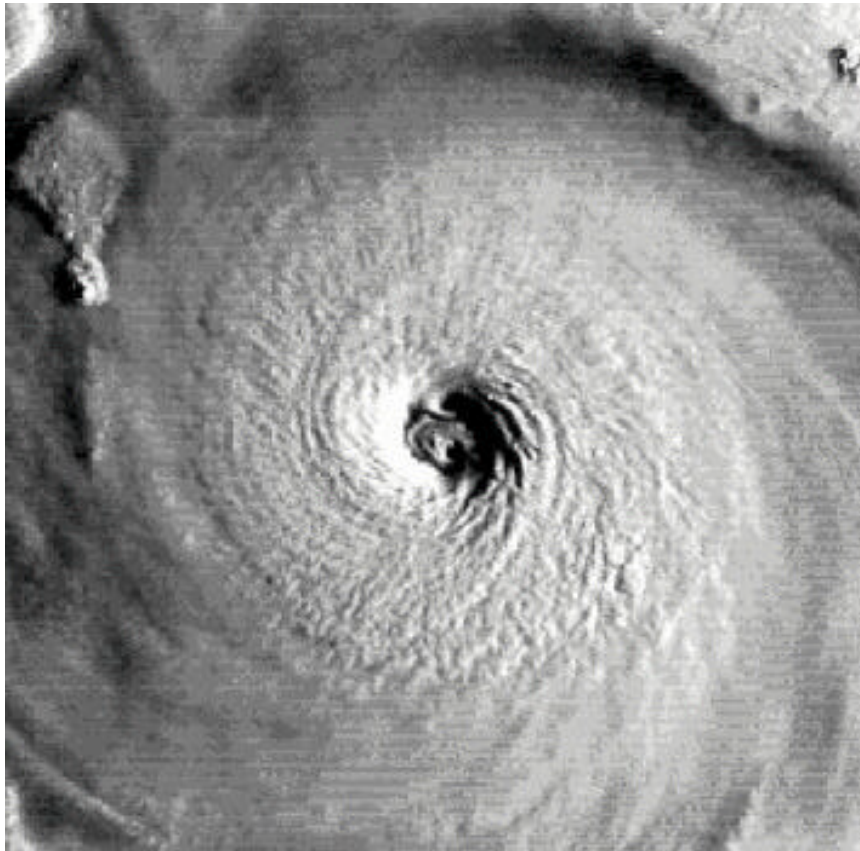


**1997**

**ANNUAL TROPICAL  
CYCLONE REPORT**



**JOINT TYPHOON WARNING CENTER**

**COVER PHOTO:** Super Typhoon Oliwa (02C), as seen by 2034Z visible GMS imagery on 9 September. The small comma shaped cloud on the inside of the eyewall is a possible manifestation of an eyewall mesovortex.

**U.S. Naval Pacific Meteorology and Oceanography Center West  
Joint Typhoon Warning Center**

**C. P. DILLON**

Captain, United States Navy  
Commanding Officer

**MARK J. ANDREWS**

Lieutenant Colonel, United States Air Force  
Director, Joint Typhoon Warning Center



*Work on this report was supported in part by  
the Office of Naval Research Grant N00014-96-1-0744*

# STAFF

## JOINT TYPHOON WARNING CENTER

LCOL	MARK ANDREWS	USAF	DIRECTOR
* LCDR	ERIC J. TREHUBENKO	USN	TDO, DEPUTY DIRECTOR
LCDR	KENNETH A. MALMQUIST	USN	TDO, DEPUTY DIRECTOR
MR	FRANK H. WELLS	CIV	TECHNICAL ADVISOR
**LCDR	STACY R. STEWART	USNR	TDO
LCDR	MARGARET A. SMITH	USN	TDO
*LT	MICHAEL S. KALAFSKY	USN	TDO
*CAPT	CARL A. MCELROY	USAF	TDO
***CAPT	CHRISTOPHER T. NICKLAS	USAF	TDO
LT	KIM F. BOYER	USN	TDO
CAPT	STEPHEN B. COCKS	USAF	TDO
*CAPT	GARY B. KUBAT	USAF	TDO
*CAPT	WILLIAM J. CARLE	USAF	TDO, STATISTICS OFFICER
LT	PAULA E. HILDEBRAND	USN	TDO
CAPT	TOM D. LUNSFORD	USAF	TDO
CAPT	CHRISTOPHER FINTA	USAF	TDO
MSGT	BRENT T. SULLINS	USAF	TDO
AG1	PAUL G. SANCHEZ	USN	LPO, SAT FORECASTER, TDA
A1C	JASON R. DOBBINS	USAF	TDA
AG2	KEYIA HALL	USN	TDA
AG2	BRYAN Y. HONG	USN	TDA
AG3	JOHN E. UROGI	USN	TDA
AG3	CAROL A. GILL	USN	TDA
SRA	SAMUEL R. PUGH	USAF	TDA
SRA	DIONNE M. TIRSCHER	USAF	TDA
SRA	MATHEW A. BOYD	USAF	TDA
SRA	RYAN M. EIBLING	USAF	SAT FORECASTER,
PROGRAMMER			
SRA	CHRISTOPHER L. JONES	USAF	TDA
AGAR	STEPHEN R. BACON	USN	TDA

## 36 OSS/OSJ

MAJ	ROGER T. EDSON	USAF	TECHNIQUE DEVELOPMENT
*CAPT	RICHARD A. ANSTETT	USAF	TDO, OIC USPACOM SAT NETWORK
MSGT	RONALD L. HOOVER	USAF	SAT FORECASTER, NCOIC
*TSGT	SHIRLEY A. BROWN	USAF	CHIEF INFORMATION MANAGEMENT
TSGT	ROBERT P. MOTZ	USAF	CHIEF INFORMATION MANAGEMENT
*TSGT	DENNIS W. MILLER	USAF	SAT FORECASTER
TSGT	ROBERT J. PATTERSON	USAF	SAT FORECASTER
*SSGT	MERRYRUTH I. DEOCARIZA	USAF	SAT FORECASTER
*SSGT	LINDA R. HAM	USAF	SAT FORECASTER
SSGT	GARTH A. MCCULLUCH	USAF	SAT FORECASTER
SSGT	IRA L. JOHNSON	USAF	SAT FORECASTER
*SSGT	BRUCE W. WOFFORD	USAF	SAT FORECASTER
*SSGT	MELISSA E. HATFIELD	USAF	SAT FORECASTER
*SSGT	CRAIG S. BOUCHILLON	USAF	DATA DEVELOPMENT
*SRA	SEAN M. MCDUNN	USAF	DATA DEVELOPMENT

## UNIVERSITY OF GUAM/JTWC RESEARCH LIAISON

DR	MARK A. LANDER	TROPICAL CYCLONE RESEARCH, TECHNICAL WRITING
MR	CHARLES P. GUARD	TROPICAL CYCLONE RESEARCH, TECHNICAL WRITING

\* TRANSFERRED DURING 1997  
 \*\* ACTIVE DUTY TRAINING  
 \*\*\* DECEASED

## FOREWARD

The Annual Tropical Cyclone Report is prepared by the staff of the Joint Typhoon Warning Center (JTWC), a combined Air Force/Navy organization. In 1997, the period covered by this report, JTWC operated under the command of the Commanding Officer, U.S. Naval Pacific Meteorology and Oceanography Center West (NAVPACMETOCCEN WEST)/Joint Typhoon Warning Center, Guam. As this is being written, however, in January of 1999, JTWC has just completed transition from Guam to Pearl Harbor, Hawaii, as mandated by the 1995 Base Realignment And Closing Commission (BRAC). JTWC now operates under the command of the Commanding Officer, U.S. Naval Pacific Meteorology and Oceanography Center (NAVPACMETOCCEN)/Joint Typhoon Warning Center, Pearl Harbor, Hawaii. This move brings to an end the forty year history of JTWC on Guam, which began on 01 May 1959 when the U.S. Commander-in-Chief Pacific (USCINCPAC) forces directed that a single tropical cyclone warning center be established for the western North Pacific region. However, our customers can anticipate the same dedicated support they have come to expect from our new locations. The operations of JTWC are guided by USCINCPAC Instruction 3140.1W.

The mission of JTWC is multifaceted and includes:

1. Continuous monitoring of all tropical weather activity in the Northern and Southern Hemispheres, from 180 east longitude westward to the east coast of Africa, and the prompt issuance of appropriate

advisories and alerts when tropical cyclone development is anticipated.

2. Issuance of warnings on all significant tropical cyclones in the above area of responsibility.
3. Determination of requirements for tropical cyclone reconnaissance and assignment of appropriate priorities.
4. Post-storm analysis of significant tropical cyclones occurring within the western North Pacific and North Indian Oceans.
5. Cooperation with the Naval Research Laboratory, Monterey, California on evaluation of tropical cyclone models and forecast aids, and the development of new techniques to support forecast requirements.

Special thanks to: the men and women of the Alternate Joint Typhoon Warning Center (AJTWC) for standing in for JTWC as needed (AJTWC will move to Yokosuka, Japan, as part of the BRAC relocation); Fleet Numerical Meteorology and Oceanography Center (FNMOC) for their operational support; the Naval Research Laboratory for its dedicated research; the Air Force Weather Agency (AFWA) and National Oceanic and Atmospheric Administration (NOAA) National Environmental Satellite, Data, and Information Service (NESDIS) for satellite support; the 36<sup>th</sup> Communications Squadron's Defense Meteorological Satellite Program (DMSP) Site 18 at Nimitz Hill, Guam (which will soon move to Andersen Air

Force Base as part of BRAC), and the Operations and Equipment Support departments of both NAVPACMETOCCEN WEST, Guam and NAVPACMETOCCEN Pearl Harbor, Hawaii, for their high quality support; all the men and women of the ships and facilities ashore throughout the JTWC area of responsibility (AOR), and especially on Guam, who took the observations that became the basis for our analyses, CDR (Ret) Lester E. Carr III and Dr. Russell L. Elsberry for their continuing efforts at the Naval Postgraduate School and their further work on the Systematic and Integrated Approach to Tropical Cyclone Track Forecasting; Dr. Robert F. Abbey Jr and the Office of Naval Research for their support to the University of Guam (UOG) for the Research Liaisons to JTWC; the UOG Research Liaisons for their contributions to this publication; Dr. Mark A. Lander for his training efforts, suggestions and valuable insights, and Mr. Charles P. Guard for

his support and data collection efforts; Dr. Jeff D. Hawkins, Chris S. Veldon, Samuel Chang and Roger Weldon for their continuing efforts to exploit remote sensing technologies in new and innovative ways; Mr. Charles R. “Buck” Sampson, Sally A. Calvert (who sadly left the team in 1998 to pursue other opportunities-she will be missed), Rosemary Lande, Mike D. Frost, Mugur Georgescu, Daren H. Grant, and Ann J. Schrader for their support and continued development of the Automated Tropical Cyclone Forecasting (ATCF) system; SRA Ryan Eibling of the JTWC staff, who used his advanced knowledge of software development to solve tough automation problems; and, LCDR Kenneth Malmquist, LCDR Margret Smith, LT Kim Boyer, Frank H. Wells, Mark A. Lander, Charles P. Guard, AG2 Keyia Hall, and AG2 Bryan Hong for their editing, desktop publishing, web publishing, and computer graphics, without which this document would not have been possible.

## EXECUTIVE SUMMARY

The Joint Typhoon Warning Center (JTWC), Guam worked very hard in 1997 to improve its data management processes. Our goal is to get the raw environmental data in-house, processed, and then displayed, in order to create finished products - warning, alert, advisory, prognostic reasoning - out (of house) to you, the user, faster, more efficiently, and with supporting, easily understood graphics. The use of the NPMOCW/JTWC Guam web site has revolutionized our ability to generate products that can be rapidly accessed. The growth of the JTWC home page has been nothing less than phenomenal -- as Super Typhoon Paka approached Guam, the web site received 107,000 "hits" in a 24-hour period. We realize this doesn't replace our primary distribution methods, but significantly augments our current capability.

We've been busy this year, but so have the tropical cyclones (TCs). In the Western North Pacific, thirty-three significant TCs occurred, two above the 37-year average of 31. Of these, 11 became super typhoons, which was a record - the 37-year average is four with seven being the previous maximum. Therefore, 1997 became the year of the super typhoon. Two of these super typhoons - Oliwa and Paka - were "borrowed" from the Central Pacific. In September, Oliwa passed through the northern Marianas and recurved over Japan, which was unusual for a Central Pacific cyclone. In December, Paka brushed by Kwajalein and Majuro before clobbering Guam.

Mean forecast track errors in 1997 continued to fall to lower values: 93 nm, 164 nm, and 247 nm at 24, 48, and 72 hours respectively - a new record. We are proud of these numbers, especially in light of continual

manning shortages. However, these values are still a long way from the goals stated by COMNAVFOR JAPAN, Admiral McKay, at the 1984 Annual Tropical Cyclone Conference of 50, 100, and 150 nm. It is sobering to note a few of this year's recurving track forecasts still had individual forecast errors in excess of 1000 nm. The bottom line is that there's still a lot which needs to be accomplished, particularly in the areas of numerical guidance, remote sensing, basic research and tropical cyclone structure and structure change.

For the North Indian Ocean, four significant TCs occurred - one less than the 21-year average of five. The Southern Hemisphere TC-year (1 July 1996 - 30 June 1997) had a bumper crop of 38, which exceeds the record of 35 set in 1985, and is 11 more than the 15-year average of 27. Of interest, none of these TCs in the North Indian Ocean and Southern Hemisphere reached super typhoon intensity.

The total number of JTWC warnings provides a measure of our workload. During 1997 there were 950 in the Western North Pacific (15-year average 712), 56 in the North Indian Ocean (15-year average 58), and 566 Southern Hemisphere (15-year average 263). Adequate JTWC manning, resources, and communications are critical to surmounting the challenge presented by years with above average workload.

Looking ahead, we're trying to speed up the delivery of our post-analysis products to you by providing them in electronic form: HTML and PDF. This product will be available via the World Wide Web and compact diskette (CD). For instance, the document that follows was assembled in HTML for the Guam web site. It is the Tropical Cyclone Summary, which provides basic statistical data for the TC-year in

review. This document will be expanded with narratives, images, and climatology as they are developed, to become in final form Chapter 3 of the 1997 Annual Tropical Cyclone Report (ATCR). In this way, ATCR chapters can be built and made available on the Internet as they are finished, without the delays of having to wait for the final complete manuscript to be printed or "burned" into a CD. Our intent in providing a PDF version of the final document along with the HTML format is to allow you to locally produce a suitable printed version if desired. However, we realize that there will be a few users out there without the capability to do this, and we will be glad to print a copy for you on request.

I would be remiss if I didn't stop to thank the members of the JTWC "team", from the researchers providing us an ever increasing amount of precious weather data and new forecast techniques, to the 32 Air Force and Navy civilian and military personnel who have tirelessly worked overtime without complaint, and for the outstanding performance achieved this past year, even though we faced many difficult situations.

To the ultimate end user of our products, the operational units both ashore and afloat, we pledge to keep our eyes and ears open as to what types of products you want, when you want it, and how you want it delivered. We realize without your support we wouldn't have a reason for existence.

In closing, there will be plenty going on and more changes planned for 1998. However at JTWC we will never lose sight of the fact that, "the forecast is our only product."

LCOL Mark Andrews  
Director, JTWC  
Jan, 1998



## TABLE OF CONTENTS

FORWARD .....	iii
EXECUTIVE SUMMARY .....	v
1. OPERATIONAL PROCEDURES.....	1
1.1 General .....	1
1.2 Data Sources.....	1
1.3 Telecommunications .....	3
1.4 Data Displays .....	6
1.5 Analyses .....	7
1.6 Forecast Procedures .....	8
2. RECONNAISSANCE AND FIXES .....	17
2.1 General .....	17
2.2 Reconnaissance Availability .....	17
2.3 Satellite Reconnaissance Summary .....	17
2.4 Radar Reconnaissance Summary .....	23
2.5 Tropical Cyclone Fix Data .....	23
3. SUMMARY OF WESTERN NORTH PACIFIC AND NORTH INDIAN OCEAN TROPICAL CYCLONES.....	26
3.1 Annual Summary .....	26

### Western North Pacific Tropical Cyclone Narratives

<u>Tropical Cyclone</u>	<u>Page</u>	<u>Tropical Cyclone</u>	<u>Page</u>
01W TS Hannah .....	44	18W TY Amber .....	77
02W STY Isa.....	46	19W STY Bing .....	81
03W TS Jimmy.....	50	20W TS Cass.....	86
04W TS Kelly.....	51	02C STY Oliwa .....	87
05W TS Levi .....	52	21W TY David .....	91
06W TY Marie .....	53	22W TY Fritz .....	93
07W STY Nestor .....	54	23W TS Ella .....	94
08W TY Opal.....	57	24W STY Ginger.....	95
09W TY Peter .....	58	25W TS Hank .....	99
10W STY Rosie.....	60	26W TD .....	100
11W TS Scott.....	61	27W STY IVAN.....	101
12W TY Tina .....	62	28W STY JOAN.....	101
13W TY Victor.....	63	29W STY KEITH.....	109
14W STY Winnie .....	64	30W TY LINDA.....	115
15W TY Yule.....	70	31W TY MORT .....	119
16W TD .....	70	05C STY PAKA .....	120
17W TY Zita .....	76		

## North Indian Ocean Tropical Cyclones

<u>Tropical Cyclone</u>	<u>Page</u>	<u>Tropical Cyclone</u>	<u>Page</u>
TC01B .....	128	TC03A.....	130
TC02B .....	129	TC04A.....	131
4.. SUMMARY OF SOUTH PACIFIC AND SOUTH INDIAN OCEAN			
TROPICAL CYCLONES .....	132		
4.1 General .....	132		
4.2 South Pacific and South Indian Ocean Tropical Cyclones .....	132		
5. SUMMARY OF FORECAST VERIFICATION .....	143		
5.1 Annual Forecast Verification .....	143		
5.2 Comparison of Objective Techniques .....	143		
5.3 Testing and Results .....	148		
6. TROPICAL CYCLONE WARNING VERIFICATION STATISTICS .....	163		
6.1 General .....	163		
6.2 Warning Verification Statistics .....	163		
7. TROPICAL CYCLONE (TC) SUPPORT SUMMARY.....	196		
7.1 Southern Hemisphere Application Of The Systematic Approach To Tropical Cyclone Track Forecasting .....	196		
7.2 Statistical Post-Processing Of NOGAPS Track Forecasts .....	197		
7.3 Automated Tropical Cyclone Forecasting System .....	197		
7.4 SSM/I Tropical Cyclone Structure .....	197		
7.5 Tropical Cyclone Scatterometer Studies .....	199		
7.6 Upper Tropospheric Outflow Patterns Over Several Very Intense Tropical Cyclones Of The Western North Pacific As Revealed By Soundings, Doppler Radar, And Water Vapor Winds .....	200		
7.7 Some Characteristics Of Tropical Cyclone Intensification As Revealed By Hourly Digital Dvorak Analysis .....	201		
7.8 Evaluation Of A Simple Technique For Predicting The Peak Intensity And The Timing Of Peak Intensity For Tropical Cyclones Of The Western North Pacific .....	201		
7.9 A Look At Global Tropical Cyclone Activity: Basin Intercomparisons And Relationships With ENSO, QBO, And Other Large-Scale Climate Features .....	203		
7.10 Techniques Incorporating SSM/I Imagery Into Dvorak Tropical Cyclone Intensity Estimates .....	204		
BIBLIOGRAPHY .....	205		
APPENDIX A – Definitions .....	208		
APPENDIX B – Names for Tropical Cyclones in the Western North Pacific Ocean and South China Sea .....	211		
APPENDIX C – Contractions .....	212		
APPENDIX D – Past Annual Tropical Cyclone Reports .....	216		